Guidelines for Industrial Landfills

Alberta
ENVIRONMENT

GUIDELINES
FOR INDUSTRIAL LANDFILLS

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1 DEFINITIONS

"Free liquids" means liquids which readily separate from the solid portion of a waste under ambient temperature and pressure as determined by Method 9095 (Paint Filter Liquids Test) described in the EPA Publication No. SW-846 "Test Methods for Evaluating Solid Wastes - Physical/Chemical Methods".

"Ground water" means subsurface water located in the saturated zone of the earth including all water in confined, unconfined or perched conditions in near surface, unconsolidated sediment or in rock formations.

"Hazardous waste" means a hazardous chemical as defined in the Hazardous Chemicals Act that is disposed of or is to be disposed of as a waste.

"Incompatible waste" means waste unsuitable for mixing with another waste or material because the mixture might produce, by chemical, physical or biological processes, products or conditions which may endanger human health or the environment.

"Industrial landfill" means a landfill which is owned and operated by a corporation, other than a municipality, a private company or an individual.

"Inert waste" means any solid waste that, when placed in a landfill, is not reasonably expected to undergo physical, chemical and/or biological changes to such an extent as to originate substances which may have a negative environmental impact.

"Landfill" means a natural and/or engineered site where wastes are deposited on land, confined to the smallest practical area, compacted, and covered with soil on a frequent basis.

"Leachate" means liquid which has percolated through or drained from solid waste and contains dissolved, suspended or microbial contaminants.

"Liner" means a continuous layer of natural (i.e., clay liners, at least one meter in thickness, with a hydraulic permeability of 1×10^{-7} cm/s or less) or man-made materials, beneath or on the sides of a landfill or landfill cell, which restricts the downward or lateral migration of the waste constituents.

"Sludge" means a mixture of solids and liquid which does not separate readily into distinct phases.

2 INTRODUCTION

The Department's objective in preparing this guideline is to establish minimum requirements for the design and operation of industrial landfills consistent with the principle of preventing ground water and surface water pollution. The requirements described in this document will be applied to "industrial landfills" established after the issuance of the guidelines. The requirements for existing sites will be dictated by a site specific evaluation of observed impacts on the environment and will incorporate necessary mitigative measures.

Approval to establish new industrial landfills or to continue operating existing industrial landfills is required from the Director of Standards and Approvals, Alberta Environment under provisions of the Clean Water Act. The guidelines in this document are the primary criteria considered by the Department in reviewing applications. Appendix 1 provides a copy of an application form for a permit to construct and a licence to operate an industrial landfill.

Sanitary landfills as defined in the Waste Management Regulations issued under the Public Health Act are equivalent to class II industrial landfills. If they are provided with a synthetic liner and a leachate collection system they can be considered equivalent to a class I industrial landfill. A dry waste site as defined in the same regulations is equivalent to a class III industrial landfill.

This document also provides the basis for the approval by the Director of Standards and Approval of municipal landfills which receive industrial or hazardous waste, according to section 33(5) of the Waste Management Regulation.

A list of hazardous wastes which are not permitted to be landfilled is attached as Appendix 4.

3 APPROVAL REQUIREMENTS

3.1 To establish and operate an industrial landfill, a permit and a licence pursuant to the Clean Water Act is required from the Director of Standards and Approvals.

3.2 A licence to operate is also required for existing industrial landfills currently in operation at industrial plant sites. The licence is to be obtained at the time of renewal of the Clean Water Act Licence if the industrial plant has such a licence or upon request from the Director of Standards and Approvals.

3.3 Application for approval is made by completing the requirements set out in Appendix 1 as follows:

A. Classes I and II: all sections of the application form are to be completed;

B. Class III: only readily available information on hydrogeology is required for sections 3 and 4; section 6 is not required; and completion required for remaining sections.

3.4 A copy of permits, licences, maps, design and operating plans should be kept at the facility office and made available to employees and government agencies on request.

4 INDUSTRIAL LANDFILL CLASSES: CRITERIA AND DESIGN

This section describes the different classes of industrial landfills, according to the types of wastes that may be accepted for disposal at the present time, and associated engineered features which supplement hydrogeologic conditions to prevent ground water and surface water contamination. Hydrogeologic and ground water evaluation criteria are outlined in Appendices 2 and 3, respectively.

4.1 Class I

This class of industrial landfill shall not accept for disposal hazardous wastes prohibited by regulation from landfill disposal and shall include the following engineered features:

A. two liners of which at least one is a synthetic liner;

B. a leachate collection and removal system;

C. a leak detection system between the two liners;

D. surface run-on and run-off control systems;

E. a suitable gas interception and venting system where gas generation is expected;

F. a ground water monitoring system consisting of observation wells located in areas hydraulically upgradient (background quality) and downgradient of the facility. The completion of the observation wells shall be at an adequate depth as to provide an indication of the potential impact of the landfill on the upper water-bearing strata.

4.2 Class II

This class of industrial landfill differs from Class I in that it may not accept for disposal any liquid hazardous waste or hazardous waste containing free liquids, as well as the other hazardous wastes prohibited by regulation from landfill disposal. However, free liquids contained in, and essential for the operation of an article such as a battery, may be disposed of in a Class II landfill.

Class II landfills shall be provided with the following features:

A. a synthetic or clay liner;

B. surface run-on and run-off control systems;

C. a suitable gas interception and venting system where gas generation is expected;

D. a ground water monitoring system consisting of observation wells located in areas hydraulically upgradient (background quality) and downgradient of the facility. The completion of the observation wells shall be at an adequate depth as to provide an indication of the potential impact of the landfill on the upper water-bearing strata.

4.3 Class III

This class of industrial landfills is restricted to inert solid wastes. Hazardous waste, waste containing free liquid, or putrescible wastes may not be disposed at these sites.

Desirable natural conditions and a surface drainage control system are required to establish and operate these landfills.

5 SITE RESTRICTIONS

The general hydrogeologic guidelines for industrial landfill site selection, presented as Appendix 2 of this document, shall be taken into consideration along with the following restrictions:

5.1 Potential sites for industrial landfills shall avoid residential areas, wetlands, permafrost areas, critical wildlife habitats, drainage ways, and areas subject to seasonal flooding.

5.2 An industrial landfill shall not be established within the 1:100 year flood plain of a stream, river or lake.

5.3 The bottom of a landfill trench or cell shall be at least 1.5 metres above the seasonally high water table. Exceptions may be considered in cases of engineered landfills or sites with very low permeability soils or geological materials.

5.4 Industrial landfills shall not be located over a buried channel aquifer unless it is demonstrated that the aquifer is protected by a substantial thickness of low permeability geological materials.

6 OPERATING REQUIREMENTS

6.1 Incompatible wastes shall be disposed of in such a way as to avoid creating hazardous conditions. Examples of incompatible wastes are presented in Appendix 5.

6.2 The frequency of covering the waste shall be carried out according to local climatic conditions and the nature of the waste disposed of to avoid creating a nuisance or hazardous condition.

6.3 Leachate, contaminated surface water and contaminated ground water shall be treated before release. Water quality parameters to be analyzed are site specific and will be defined in the licence to operate.

6.4 Water which accumulates in a landfill trench, as a result of precipitation, shall be removed to avoid contact with the waste.

6.5 The objective in operating an industrial landfill is that the ground water quality hydraulically downgradient at the site's boundary remains the same as that upgradient, or it does not exceed the health related parameters of the Guidelines for Canadian Drinking Water Quality. In addition, background water quality parameters must not be exceeded in adjacent ground water supply wells.

6.6 Top soil removed during the operation of the industrial landfill may be stockpiled and stored in such way as to minimize erosion, for use at the closure stage as final cover material for revegetation.

6.7 Suitable fire protection services shall be available to extinguish fires immediately upon detection.

6.8 Access to an industrial landfill shall be restricted to authorized personnel, and controlled by the operator.

7 MONITORING AND REPORTING REQUIREMENTS

Ground water monitoring must be defined at the design stage of an industrial landfill and data reflecting background conditions shall be obtained prior to commencement of operation. Later on, the monitoring program will provide information to assess performance and to quantify impacts on the surrounding ground water. The following should be considered in developing a monitoring strategy for an industrial landfill.

7.1 The background quality of ground water and surface water in the potential zone of influence of classes I and II industrial landfills shall be determined prior to operation of the landfill.

7.2 Samples shall be taken from the ground water monitoring and leachate collection systems at least twice a year for chemical analysis. Typically, the analyses required may include some or all of the following parameters:

A. pH (field and laboratory values);
B. major ions (calcium, magnesium, sodium, potassium, chloride, nitrate, and sulphate);
C. chemical oxygen demand;
D. total organic carbon;
E. total dissolved solids;
F. oil and grease;
G. electrical conductivity; and
H. specific tests included in the licence to operate based on the type of wastes being disposed.

Long term analytical requirements are dependent on previous monitoring results and subject to adjustments with the renewal of the licence to operate.

7.3 Before sampling, the water level in the observation well shall be recorded and the water bailed out at least one well volume to ensure that a representative sample of ground water is obtained.

7.4 Analyses of all samples shall be conducted either:

A. in the manner described in the publication "Standard Methods for the Examination of Water and Wastewater", 16th Edition (1985) or the most recent edition, published jointly by the American Public Health Association, American Water Works Association, and the Water Pollution Control Federation; or

B. in the manner described in the "Methods Manual for Chemical Analysis of Water and Wastes" (1987), published by Alberta Environment; or

C. by any other equivalent method which has been approved in writing by the Director of Standards and Approvals.

7.5 The owner/operator of an industrial landfill will be required by his Licence to Operate to forward to the Director of Pollution Control, at the end of each year a report which shall include:

A. location, amounts, and physical and chemical description of the waste disposed of; and

B. the monitoring data obtained pursuant to this section.

8 CLOSURE AND POST-CLOSURE REQUIREMENTS

8.1 The Minister of Environment may require the posting of a bond or some other form of financial security, which will provide the owner with the means to prepare the site for future safe use. Special consideration is given to the financial and professional reliability of the licencee in requiring the posting of financial security.

8.2 At closure of the industrial landfill, the owner/operator may be required to remove the waste and any contaminated soil, if it is determined that the conditions of the site are not compatible with the proposed land use.

8.3 At closure, a cover consisting of approximately one meter of silty clay underlying a minimum of 0.30 metres of top soil shall be placed over the landfill and a suitable vegetation cover shall be established to prevent erosion.

8.4 For industrial landfills classes I and II, the cover design shall minimize the amount of water that may percolate into the waste and shall be supported by a water balance calculation, based on a 10-year storm record for a 24-hour duration.

8.5 The final surface shall be graded such that water does not pool over the landfill, with a final grade which is not to exceed 15%.

8.6 During the post-closure period, which will continue for a period of 20 years or as long as leachate is generated, the owner/operator of the landfill will be required to:

A. maintain the integrity of the final cover and all diversion and drainage structures;

B. maintain and operate the ground water monitoring and leachate collection systems where such systems are installed; and

C. maintain records of the wastes disposed of at the site.

REFERENCES

Environmental Protection Agency, 1987. "EPA Regulations for Owners and Operators of Permitted Hazardous Waste Facilities". 40 CFR 264, Environment Reporter. Published by the Bureau of National Affairs, Inc., Washington, D.C. 20037.

Hvorslev, M.J., 1951 "Time Lag and Soil Permeability in Groundwater Observations" Bulletin No. 36. Waterways Experiment Station, Corps of Engineers, U.S. Army. Vicksburg, Mississippi.

Mather, J.D., 1976. "Licencing of Waste Disposal Sites". Department of the Environment, U.K. Institute of Geological Sciences, Waste Management Paper No. 4, Appendix 1.

M.M. Dillon Ltd., 1983. "Landfilling of Hazardous Wastes". Prepared for Environment Canada.

NATO Committee on the Challenges of Modern Society, 1977. "Disposal of Hazardous Wastes Landfill".

Todd, D.K., 1959. "Ground Water Hydrology". John Wiley & Sons, Inc., New York.

APPENDIX 1

APPLICATION FORM FOR APPROVAL OF AN INDUSTRIAL LANDFILL

THE CLEAN WATER ACT

Application for a Permit or Licence

TO: ALL APPLICANTS FOR AN INDUSTRIAL LANDFILL APPROVAL

1. All sections to be completed by applicant.

2. The completed application and attachments are to be sent to:

Director of Standards and Approvals
Standards & Approvals Division
Alberta Environment
4th Floor, Oxbridge Place
9820 - 106 Street
EDMONTON, ALBERTA
T5K 2J6

THE CLEAN WATER ACT

APPLICATION FOR APPROVAL OF AN INDUSTRIAL LANDFILL

Application No.: _____

Date Received: _____

Reviewed by: _____

FOR OFFICE USE ONLY

Section One: General Information

1.1 Date of application: _____

1.2 Name, address and phone number of applicant: _____

_____

1.3 Name, address and phone number of owner/operator: _____

_____

1.4 Legal land description of disposal site: _____

_____

1.5 Current land use and zoning: _____

_____

1.6 Applications for:

A. A permit to construct _____

B. A licence to operate _____

1.7 Summary of project: _____

_____

_____

_____

1.8 Duration of project: _____

_____

Section Two: Geographical Features

Scale diagrams of the industrial landfill site and surrounding area are required. These diagrams shall include:

2.1 Topography of the area;

2.2 Landfill boundaries, buffer zones, and land use of the area;

2.3 Location of all water bodies and water supply wells within 500 m radius of the site.

Section Three: Geological Characteristics

The description of the surficial and bedrock geology shall include:

3.1 Classification, hydraulic conductivity, and liquid absorption capacity of the soil;

3.2 Lithologic description and hydraulic characteristics of the geologic formations to a depth of at least 15 m below ground surface.

Section Four: Hydrogeological Characteristics

The following information shall be included in the description of the local hydrogeology:

4.1 Water table level;

4.2 Ground water flow directions and rates;

4.3 Background quality of ground water in the upper water-bearing strata within the expected zone of influence;

4.4 Present ground water uses which could be affected.

Section Five: Design Considerations

A description of types, characteristics and quantities of wastes as well as details on the industrial landfill design shall include:

5.1 Production rate of each waste stream;

5.2 Physical and chemical characteristics of each waste stream;

5.3 Description of disposal methods;

5.4 Detailed landfill design;

5.5 Physical and chemical properties of liners, and intermediate or final covers;

5.6 Potential of materials described in 5.5 to retard movement and/or provide neutralization of waste components.

Section Six: Monitoring System

A full description of the ground water monitoring system for the industrial landfill shall include:

6.1 Proposed number and location of ground water observation wells (as a minimum, one well hydraulically upgradient of the site and two wells downgradient are required);

6.2 Details on the completion of observation wells (depth, screening interval, construction material, casing and annular seals).

Section Seven: Closure and Reclamation

A discussion regarding closure procedures, reclamation of the site, and the planned end use of the land shall be provided.

Section Eight: Local Authority Approval

Provide copy of development permit.

Section Nine:

This application is submitted in accordance with the Clean Water Act and may require the applicant to submit any additional information considered necessary regarding the proposed industrial landfill.

An application for a Permit or Licence shall not be deemed to be complete until all the information, documents and authorizations in the application form have been received.

_____

(Date)

_____

(Signature)

_____

(Title of Signature)

NOTE: The application must be signed by the owner or his agent.

APPENDIX 2

GENERAL HYDROGEOLOGIC GUIDELINES FOR INDUSTRIAL LANDFILL SITE SELECTION

GENERAL HYDROGEOLOGIC GUIDELINES FOR INDUSTRIAL LANDFILL SITE SELECTION

1 INTRODUCTION

The following hydrogeologic guidelines have been developed to identify suitable sites for the location of an industrial landfill.

A fundamental problem inherent to the development of site selection guidelines lies in the fact that each site under consideration represents an unique hydrogeological environment. A guideline parameter which is important in one type of geological setting may assume a lesser or greater importance in a different setting. Due to the variability of hydrogeological environments and the interdependency of site selection parameters, all of the site parameters must be evaluated simultaneously prior to determining the final hydrogeological site suitability. Therefore, only general guidelines can be established and prospective sites must be evaluated on an individual basis.

The following is a generalized outline of physical and hydraulic parameters which must be considered in a site evaluation. Ratings include: "desirable", "undesirable" and "questionable". The "questionable" category is a borderline rating that can be given to parameters which are marginally less than desirable but whose potential negative effect may be offset by another parameter. A site with one "questionable" parameter may still be rated as hydrogeologically suitable depending on the evaluation of all other site parameters. In isolated cases a site with an "undesirable" parameter may similarly be rated as suitable.

2 TOPOGRAPHY AND LANDFORMS

A. Desirable - Level to undulating to gently rolling plains.

B. Undesirable - Steep slopes, depressions where water accumulates, ravines and gullies, stream/river terraces and flood plains, lakeshores.

3 GEOLOGY

3.1 Surficial geology

A. Desirable - Materials likely to exhibit low hydraulic conductivities of 1×10^{-6} cm/s or less, e.g. lacustrine clay deposits and clay till.

B. Undesirable - Materials with hydraulic conductivities greater than 1×10^{-6} cm/s, e.g. sandy silt, sand, gravels.

3.2 Bedrock geology

A. Desirable - Materials with a low hydraulic conductivity (1×10^{-6} cm/s or less), e.g. shale.

B. Undesirable - Materials with hydraulic conductivities greater than 1×10^{-6} cm/s, e.g. clean sandstones, fractured bedrock.

3.3 Thickness of native materials with "desirable" hydraulic conductivity

A. Desirable - Greater than 10 m.

B. Undersirable - Less than 10 m.

4 HYDROGEOLOGY

4.1 Aquifer yields

A. Desirable - Areas underlain by aquifers, either surficial or bedrock, where the apparent 20 year yield (Q_{20A}) is less than 9 L/min.

B. Questionable - Areas underlain by aquifers where the Q_{20A} is between 9 and 45 L/min.

C. Undesirable - Areas underlain by aquifers where the Q_{20A} exceeds 45 L/min.

4.2 Ground water flow

A. Desirable - Discharge areas where it can be demonstrated that surface water will not be affected by mobilized contaminants, or transitional areas where there will not be significant lateral transfer of mobilized contaminants.

B. Questionable - Ground water recharge areas.

4.3 Depth to water table

A. Desirable - Areas where the vertical separation between the seasonal high water table and the trench bottom is greater than 1.5 m.

B. Questionable - Areas where the vertical separation between the water table and the trench bottom is less than 1.5 m.

APPENDIX 3

GROUND WATER EVALUATION
AND DETAILS FOR CONSTRUCTION OF OBSERVATION WELLS

GROUND WATER EVALUATION
AND DETAILS FOR CONSTRUCTION OF OBSERVATION WELLS

1 INTRODUCTION

The potential impact on ground water resources is one of a number of factors which require consideration during the site selection and operation phases of industrial landfills. To achieve this objective, an investigation standard must be established to obtain the necessary hydrogeologic data to properly evaluate each site. The following is a generalized outline of the data necessary for this evaluation. Since each site represents an unique hydrogeologic environment, the number and position of testholes and observation wells is dependent on existing site conditions. Therefore, only general guidelines can be established and investigations must be designed on a site-specific basis.

Prior to embarking on a field program, the general hydrogeology of the site must be investigated by a review of available data. This review should establish the regional hydrogeologic setting within a three kilometer radius of the proposed site by presentation of lithologic information, identification of water well locations and aquifer yields. The actual placement of instrumentation will be dependent on the site geology, determined during the drilling phase. To ensure an adequate number of wells, the proper positioning of wells, and accurate site evaluation, the investigation should be supervised or conducted by personnel experienced in ground water investigations (preferably a hydrogeologist).

2 GROUND WATER OBSERVATION WELLS

2.1 Piezometers

Observation wells are classified as either piezometers or water table wells depending on construction. Piezometers are used to:

A. isolate a specific zone to enable sampling of ground water;

B. measure the hydraulic potential at specific points below the water table. Short sections of screen (0.5 to 1.0 m) are placed opposite the zone to be monitored and all zones above and below the screen are sealed off. Groups of piezometers, or nests, are often used to determine the hydraulic potential at different depths, thus enabling the determination of the vertical component of ground water flow (recharge, discharge or lateral flow conditions). A piezometer in combination with a water table well can also be used provided the water table is not perched; and

C. determine the hydraulic conductivity of the geologic materials where the piezometer has been completed, by conducting a dynamic response test or "slug test". Data are most commonly interpreted using the method devised by Hvorslev (1951).

2.2 Water Table Wells

The upper surface of the zone of saturation is called the water table. It can further be defined as "the surface of atmospheric pressure and would be revealed by the level at which water stands in a well" (Todd, 1959). The shape of the water table generally tends to follow the topography of the land.

Water table wells are observation wells, which contain long sections of slotted pipe, allowing the entry of ground water along most of the well depth. Water table wells are used primarily to determine the water table depth and the lateral direction of ground water flow. The slotted section of water table wells should extend above the anticipated water table depth but should not extend large distances below the water table. Should the well screen or slotted interval extend to a confined permeable zone below the water table, the water level in the observation well may reflect the hydraulic potential of the more permeable zone.

Due to annual fluctuations in the water table level, the specific results of a water table observation well network should be evaluated with respect to other attributes of the site gathered by site inspection and examination of aerial photographs. A number of factors, such as weather, surficial stratigraphy, topography and flooding, affect the water table level. Vegetation type and soil development tend to reflect the interplay of these factors and the resultant long-term range of water table levels.

2.3 Stabilization of Water Levels

It is essential that observation well water levels have stabilized prior to using the data for preparing water table contour maps, assessing the vertical component of ground water flow and the calculation of ground water velocities. The stabilization period is dependent primarily upon the permeability of geologic materials. For example, wells completed in sand and gravel may stabilize within minutes while wells completed in clays can take several months to stabilize. Stabilization can be determined by assessing the relative change in water level between successive water level measurements conducted over a period of time.

2.4 Density of Observation Wells and Depth of Investigation

As previously stated, the density and positioning of observation wells is dependent on the hydrogeology of the site. The following can be used as a general guide:

A. It is recommended that observation wells be completed on a 200 m grid spacing [equivalent to 25 drill locations on 160 acres (64.8 ha)]. Generally a water table well would be completed at each drill site to define the water table.

B. The surficial and bedrock materials throughout the site should be identified in detail to a depth of at least 15 m below ground surface. One deeper testhole to at least 30 m below ground surface is highly desirable and may be required, dependent on the review of published and unpublished data. For example, if preglacial sand and gravel deposits are expected at those depths, a test hole would be required for confirmation.

3 SITE MAPPING

Using the above criteria the following site maps should be prepared:

- site topography map;
- depth to water table map; and
- water table contour map.

The maps should show the location and elevation of all observation wells (the wells must be surveyed) and other details of significance to site developement. If bedrock is intersected during the investigation, a fourth map, bedrock topography should be prepared. One or more representative hydrogeologic cross sections through the site are also required. Other maps that could be prepared dependent on site conditions include depth-to-bedrock and isopach maps for specific surficial materials.

4 DETERMINING GROUND WATER VELOCITY

Single well response tests (slug tests) should be conducted in all piezometers in order to obtain representative in-situ hydraulic conductivities for various geologic materials within the depth of investigation. A textural analysis (sieve or hydrometer) of surficial materials taken at various intervals would supplement hydraulic conductivity determinations. As previously stated, a piezometer nest should be installed in at least one location to record the hydraulic potential at different depths, thus enabling the vertical component of ground water flow to be determined.

Ground water flow velocity (linear pore water velocity-based on Darcy's law) is a function of hydraulic conductivity, hydraulic gradient and porosity of the porous medium; and is calculated as follows*:

$$Vw = \frac{K \frac{dh}{dl}}{\theta}$$

where Vw = average velocity of ground water through pores;
K = hydraulic conductivity (from slug tests conducted on piezometers);

$\frac{dh}{dl}$ = mean hydraulic gradient (slope of the water table);

θ = porosity (based on type of material).

* Todd (1959)

5 CONSTRUCTION OF OBSERVATION AND MONITORING WELLS

5.1 Well Construction Materials

Plastic PVC pipe is recommended for the construction of water table wells and piezometers. Casing with an inside diameter of 3.8 cm to 5.0 cm is most often used for completing observation and monitoring wells (see Figures I and II for construction details).

5.2 Piezometer Screens

A wide variety of piezometer screens (metal and plastic) are available commercially. Plastic screens are most commonly used in constructing wells for landfill monitoring. The full length of screen must be backfilled with sand of suitable grain size. The sand should be coarse enough that it does not enter the screen but fine enough to result in some filtration.

5.3 Water Table Well Screens

Water table wells are screened or slotted along much of their length as indicated previously. In order to reduce costs, water table wells are usually constructed by slotting the well casing with a hacksaw. The annular space around the perforated section is then backfilled with either coarse sand or pea gravel.

5.4 Annular Seals

The annular space between the casing and the testhole must be sealed immediately above the piezometer screen to prevent hydraulic communication between different zones and also to prevent contamination by surface water. Bentonite clay (montmorillonite) is probably the most effective material for use as an annular seal since the bentonite swells when wet to form an excellent seal. The sand pack surrounding the piezometer screen should be extended 15 to 20 cm above the screen to limit the entry of bentonite into the screened zone. A 15 to 20 cm layer of bentonite pellets is then placed on top of the sand pack, and the remaining annular space filled with cuttings. A bentonite seal should be placed at the surface for both piezometers and water table wells to prevent contamination by surface water.

5.5 Well Development

Prior to sampling, wells should be developed by bailing, flushing or pumping. The internal casing pressure must be minimized to avoid annular seal damage.

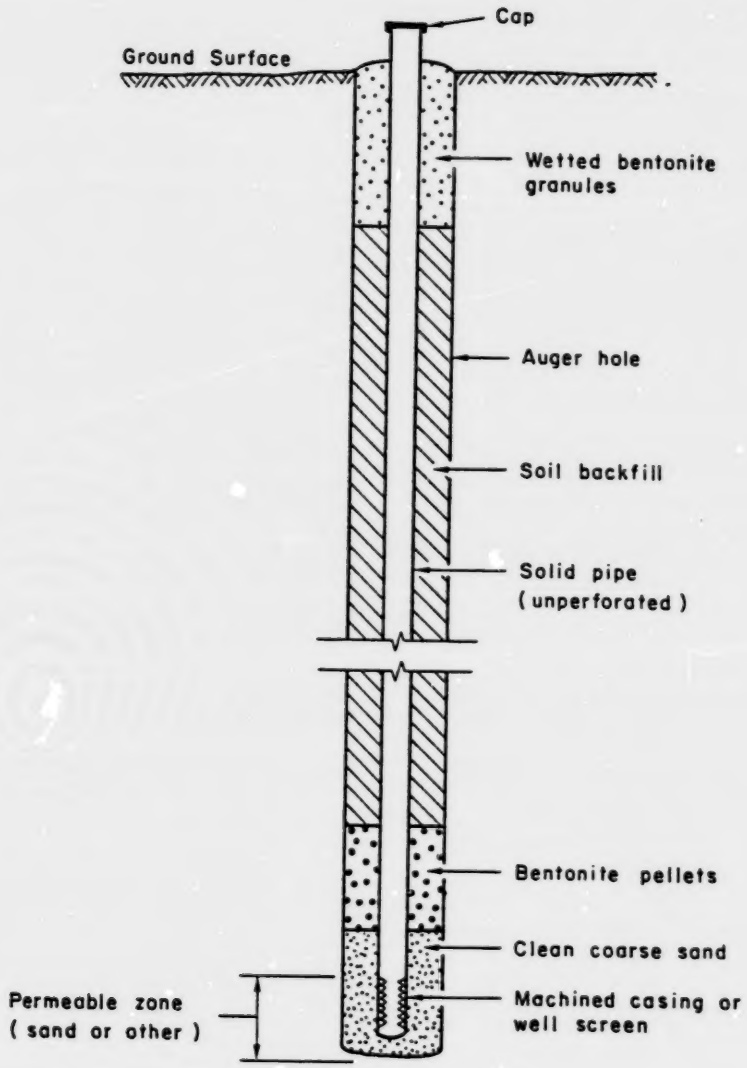

Figure I. Piezometer construction details

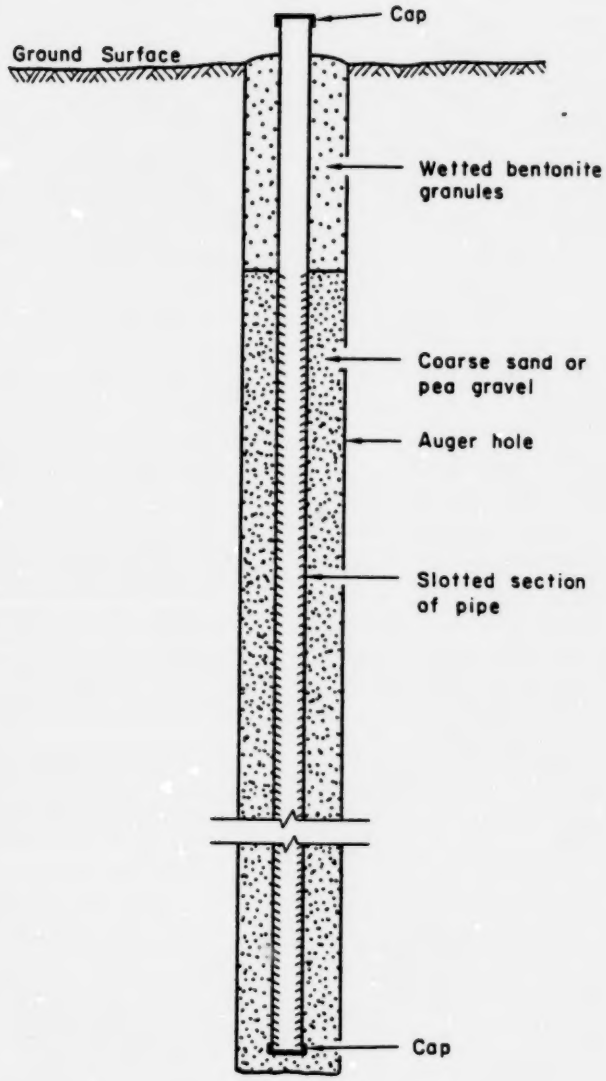

Figure II. Water table well construction details

6 BACKGROUND QUALITY OF GROUND WATER

Should the site be approved, ground water samples will be required to assess background water quality prior to landfill development. The requirement for ground water monitoring should be considered during completion of observation wells so that the wells could later be incorporated into a ground water monitoring system.

APPENDIX 4

HAZARDOUS WASTES PROHIBITED FROM LANDFILL DISPOSAL

HAZARDOUS WASTES PROHIBITED FROM LANDFILL DISPOSAL

The Hazardous Waste Regulation should be consulted to determine hazardous wastes which are prohibited from landfill disposal.

APPENDIX 5

EXAMPLES OF POTENTIALLY INCOMPATIBLE WASTES

EXAMPLES OF POTENTIALLY INCOMPATIBLE WASTE

Many wastes, when mixed with other waste or materials at a waste facility, can produce effects which are harmful to human health and the environment, such as

A. heat or pressure,
B. fire or explosion,
C. violent reaction,
D. toxic dusts, mists, fumes, or gases, or
E. flammable fumes or gases.

Below are examples of potentially incompatible wastes, waste components, and materials, along with the harmful consequences which result from mixing materials in one group with materials in another group. The list is intended as a guide to owners or operators of industrial landfills, to indicate the need for special precautions when managing these potentially incompatible waste materials or components.

This list is not intended to be exhaustive. An owner or operator must adequately analyze his waste so that he can avoid creating uncontrolled substances/reactions of the type listed below, whether they are listed below or not.

It is possible for potentially incompatible wastes to be mixed in a way that precludes a reaction (e.g., adding acid to water rather than water to acid) or that neutralizes them (e.g., a strong acid mixed with a strong base), or that controls substances produced (e.g., by generating flammable gases in a closed tank equipped so that ignition cannot occur, and burning the gases in an incinerator).

In the lists below, the mixing of a Group A material with a Group B material may have the potential consequence as noted.

Group 1-A	Group 1-B
Acetylene sludge	Acid sludge
Alkaline caustic liquids	Acid and water
Alkaline cleaner	Battery acid
Alkaline corrosive liquids	Chemical cleaners
Alkaline corrosive battery fluid	Electrolyte, acid
Caustic wastewater	Etching acid liquid or solvent
Lime sludge and other corrosive alkalies	Pickling liquor and other corrosive acids
Lime wastewater	Spent acid
Lime and water	Spent mixed acid
Spent caustic	Spent sulfuric acid

Potential consequences: Heat generation; violent reaction.

Group 2-A	Group 2-B
Aluminum	Any waste in Group 1-A or 1-B
Berylium	
Calcium	
Lithium	
Magnesium	
Potassium	
Sodium	
Zinc powder	
Other reactive metals and metal hydrides	

Potential consequences: Fire or explosion; generation of flammable hydrogen gas.

Group 3-A	Group 3-B
Alcohols	Any concentrated waste in Groups 1-A or 1-B
Water	Calcium
	Lithium
	Metal hydrides
	Potassium
	SO_2Cl_2, $SOCl_2$, PCl_3, CH_3SiCl_3
	Other water-reactive waste

Potential consequences: Fire, explosion, or heat generation: generation of flammable or toxic gases.

Group 4-A	Group 4-B
Alcohols	Concentrated Group 1-A or 1-B wastes
Aldehydes	Group 2-A wastes
Halogenated hydrocarbons	
Nitrated hydrocarbons	
Unsaturated hydrocarbons	
Other reactive organic compounds and solvents	

Potential consequences: Fire, explosion, or violent reaction.

Group 5-A	Group 5-B
Spent cyanide and sulfide solutions	Group 1-B wastes

Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulfide gas.

Group 6-A

Chlorates
Chlorine
Chlorites
Chromic acid
Hypochlorites
Nitrates
Nitric acid, fuming
Perchlorates
Permanganates
Peroxides
Other strong oxidizers

Group 6-B

Acetic acid and other organic acids
Concentrated mineral acids
Group 2-A wastes
Group 4-A wastes
Other flammable and combustible wastes

Potential consequences: Fire, explosion, or violent reaction.

Source: "Law, Regulations, and Guidelines for Handling of Hazardous Waste." California Department of Health, February 1975.